Screening and interface effects in oxide nanostructures

Beamline: X1B

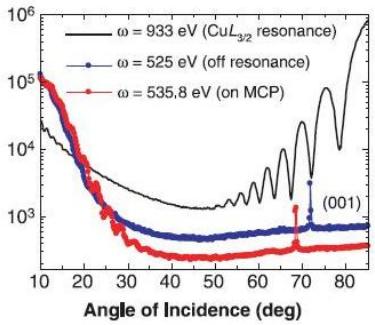
Technique:
Resonant soft x-ray scattering (RSXS); Molecular beam epitaxy (MBE)

Researchers:
P. Abbamonte, I. Bozovic, G. Logvenov, A. Gozar

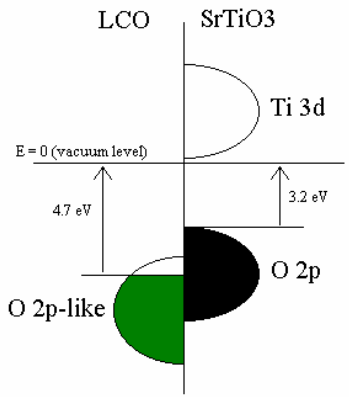
Publication:
"A structural probe of the doped holes in copper-oxide superconductors", P. Abbamonte, L. Venema, A. Rusydi, G. A. Sawatzky, G. Logvenov, I. Bozovic, *Science*, **297**, 581 (2002)

Motivation: Transition metal oxides (TMO) exhibit a variety of exotic phenomena, such as high temperature superconductivity. However such phenomena are only useful if intergrated into a device.

TMO's are highly polar, consisting of di- and trivalent ions, and are therefore more susceptible to screening and interface effects than, for example, Si-based devices.

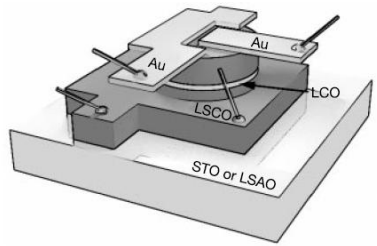


On-specular RSXS scans from a thin film of La_2CuO_{4+y} on $SrTiO_3$, on the CuL_3 resonance, the oxygen mobile carrier resonance, and off-resonance. From the envelope of the interference fringes we have determined that the interface is structurally sharp, but electronically smooth, indicating the existence of a depletion zone.



Schematic nergy level structure of La_2CuO_{4+y} compared to $SrTiO_3$. Charge transfer is expected between the two materials, driving the La_2CuO_{4+y} insulating in close proximity to the interface.

Results: We have recently shown that resonant soft x-ray scattering (RSXS) is directly sensitive to valence electron ordering at the nanoscale in artificially structured transition metal oxides. Specifically, we have shown that the interface between a thin fiilm of La_2CuO_{4+y} (LCO) and $SrTiO_3$ (STO) contains a depletion region, explaining why the first few units cells of LCO on STO tend to be insulating. In this project we are investigating in the general sense how engineered nanostructure, surface termination, and interface effects modulate the electron density in TMO nanostructures and influence the transport properties of devices. This project is an important precursor to the correlated oxide thrust effort at BNL's Center for Functional Nanomaterials (CFN).



Device used to test possible mixing between antiferromagnetic and superconducting order parameters in copper-oxides, reproduced from I. Bozovic, et. al., *Nature*, 422, 873 (2003). Knowledge of electronic structure of interfaces is essential for application of such devices.